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College of Sciences

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Nanotechnology

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MSc. Nano-Biotechnology

Lab. 7: Biological effects of nanoparticles

A) Nanomaterials applications and some Current Products

1- Carbon nanoparticles: Fabrics, Cosmetics, Electronics, Sports Equipment, Building Materials, Food Supplements, Food Flavorings.

2- Silver: Antibacterial, Antifungal, Self-Cleaning Glass, Food Storage Containers, Hygiene Products, Bandages.

3- Silica: Electronics, Paints/Pigments, Cosmetics, Food Supplements.

4- Zinc Oxide and Titanium Oxide: sunscreens, Cosmetics, Self-Cleaning Coatings.

5- Gold: Chemical Detection, Home Pregnancy Tests, Wrinkle Reducing Skin Cream.

B) Toxicity Concerns of Nanomaterials

Sources of nanoparticles

1. Natural sources of nanoparticles

Nanoparticles are abundant in nature; as they are produced in many natural processes, including photochemical reactions, volcanic eruptions, forest fires, and simple erosion, and by plants and animals.

2. Anthropogenic nanomaterial

Humans have created nanomaterials, as they are byproducts of simple combustion (with sizes down to several nm) and more recently, chemical manufacturing.

combustion in vehicle and airplane engines, combustion of treated pulverized sewage sludge, and combustion of coal and fuel oil for power generation.

► Nanoparticles might enter the body by

1- Inhalation 2- Ingestion 3- Through the skin 4- Following introduction of material in foods 5- In some medical procedure, for example implantation of a prosthetic joint.

► Factors which are thought to make nanoparticles toxic are:

a) Large surface area, adsorbed organic molecules and metals

b) Solubility

Effect on human health

Oxidative stress and Cytotoxicity

Nanomaterials are known to cause oxidative stress as a mechanism of toxicity. This increase in Reactive Oxygen Species (ROS) can be irreversibly harmful to cells causing membrane damage, protein oxidation, DNA damage, mitochondrial dysfunction, apoptosis, and genotoxicity.

In vitro and in vivo characterization

For **in vitro** characterization, nanomaterials may be assayed in biological matrices such as blood, plasma, cells, or primary culture.

Some in vitro tests that may be performed include:

1- Sterility check (e.g., testing for the presence of bacteria, virus or mycoplasma)

2- Blood contact properties (e.g., plasma protein binding, hemolysis, coagulation, complement activation, cytotoxic activity of NK cells).

3- Cell uptake and distribution (e.g., cell binding, NP internalization)

4- Toxicity (enzyme induction or suppression testing, oxidative stress, apoptosis testing, necrosis testing).

► The amount of information obtained by in vitro testing is limited.

In addition to in vitro testing, NPs that will be used for biomedical/clinical applications (e.g., therapeutics, in vivo diagnostics) have to be tested in animal models.

In vivo assays can provide essential information regarding what may happen when the NPs are inside the body.

Some in vivo tests that may be performed include

1- Dose-response

2- Bio- distribution;

3- Acute and multi dose efficacy

4- Safety

5- Administration route determination

6- Absorption, Distribution, Metabolism, and Excretion (ADME).

• **The ultimate goal of in vitro and in vivo testing is to match the physicochemical parameters of the NPs to its biological function.**